INVESTIGATING THE CONCRETE PROPERTIES WITH AND WITHOUT ADDITIVES

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Abstract - *This study embarked on a comprehensive exploration of the influence of rice husk ash as a replacement for fine aggregates in concrete samples. Beginning with an in-depth literature review, the research delved into the mix design process, understanding the pivotal components for concrete preparation. Various tests, including compressive strength, slump, and sieve analyses, were conducted, adhering to the Indian Standard approach. The study's focal point was the replacement of fine aggregates with rice husk ash in proportions ranging from 0% to 2%. The results showcased a notable enhancement in both compressive and flexural strengths with a 1.5% rice husk ash replacement, making it the optimal choice. After 28 days of curing, this mix exhibited the highest compressive strength of 47.06 N/mm² and a flexural strength of 6.63 N/mm². The research concludes that concrete mixed with 1.5% rice husk ash offers superior mechanical properties, marking its potential for sustainable construction applications.*

Key Words: Rice Husk Ash, Compressive Strength, Flexural Strength, Concrete Mix Design, Fine Aggregates, Slump Test, Sieve Analysis.

1.INTRODUCTION

Concrete is everywhere around us, from bridges to buildings to roads. This versatile material is made up of cement, water, sand, and aggregates that are mixed in specific ratios to produce fresh concrete. As it undergoes the curing process, it hardens into a solid structure. Adding additives to concrete has become increasingly popular today. A variety of additive-s are available in the market, such as fly ash, brick dust, and rice husk ash. Among them, rice husk ash is highly sought-after for its affordability and accessibility. In construction projects, it's common to partially substitute sand with rice husk ash since it enhances concrete properties like strength and ductility. This results in more resilient structures that can withstand time and external forces.

2. LITERATURE SURVEY

The utilization of fly ash in concrete mix designs has been a topic of interest for researchers over the years. Abrams, in 1918, proposed the water-cement ratio law, which did not consider the effects of fly ash and silica fume as they were virtually unknown during that time [1]. However, Oluokun's study in 1994 found that Abrams' law is not directly applicable to mixes with fly ash, suggesting an alternative augmented water-cementitious materials ratio law for such mixes [1].

In 2003, Siddhique conducted an experimental investigation to evaluate the mechanical properties of concrete mixtures where fine aggregate (sand) was partially replaced with Class F fly ash [2]. The study revealed significant improvement in the strength properties of plain concrete with the inclusion of fly ash as a partial replacement of fine aggregate [2].

Limbachiya et al., in 2012, discussed the environmental benefits of using recycled concrete aggregate in fly-ash concrete [3]. Their study showed that while embedding a high amount of recycled concrete aggregate could lower the resistance to chloride penetration and carbonation of concrete, it still achieved a comparable design strength to that of the control mix [3].

Sarker and Nath, in 2011, investigated the durability properties of high strength concrete utilizing high volume Class F fly ash [4]. Their results indicated that the inclusion of fly ash reduced sorptivity and chloride ion permeation significantly, thereby improving the durability properties of concrete [4].

Lastly, Kayali and Haque, in 1998, used a Class F fine fly ash to produce workable high-strength concrete [5]. Their study found that the optimum cement replacement for both 400 and 500 kg total cementitious material mixtures was 10%, with the 28-day maximum strength for the two optimum mixtures being 94 and 111 MPa, respectively [5].

3. OBJECTIVE OF THE WORK

The endeavor's principal intention was to conduct an in-depth investigation of evaluating and investigation of the concrete by the addition of rich husk ash,

- To uplift the workability of the concrete by finding the appropriate ratio of the additives,
- To surge up the physical as well as mechanical characteristics of the concrete by considering the best material available,

4. Methodology

a) **Preliminary Research**:
- Reviewed hard copies including books and academic notes.
- Studied soft copies such as online journals and dissertations.
- Gained understanding about concrete, its components, and its use in civil engineering.
- Familiarized with the mix design process and various chemicals used in concrete.

b) **Material Collection**:
- Gathered OPC cement of grade 43.
- Sourced fly ash to enhance workability and durability.
- Collected aggregates of varied sizes and shapes.
- Reviewed IS codes for experiment guidelines.
- Conducted sieve analysis as per IS 2386-1 (1963).
- Calculated mix design for M30 concrete based on IS 10262-1982.

c) **Aggregate Impact Value Test**:
- Used 1 kg of 10 mm aggregates from sieve analysis.
- Measured weight of the empty mold (W1).
- Compacted aggregates in a measuring cylinder in three layers.
- Calculated combined weight of mold and sample (W2).
- Conducted impact test and sieved material through a 2.36 mm sieve to get weight (W3).
- Calculated impact value using the given formula.

d) **Concrete Mixing and Slump Test**:
- Mixed concrete with varying proportions of rice husk ash (0, 0.5, 1, 1.5, and 2%).
- Conducted slump test using a 30.48 cm-tall slump cone mold.

e) **Material Preparation and Curing**:
- Poured concrete into cubical molds of specified sizes.
- Vibrated samples to remove voids.
- Allowed samples to cure in the lab for 24 hours.
- Demolded samples and cured in water tanks for 7 and 28 days.

f) **Strength Tests**:
- Conducted compressive strength test on cured samples.
- Performed flexural strength test on rectangular mold as per Indian standard.

g) **Data Analysis**:
- Calculated and recorded aggregate impact value, flakiness index, elongation index, compressive strengths, and flexural strengths.
- Identified the concrete mix with 1.5% fly ash as exhibiting the best compressive and flexural strengths.

4. Material Required

Table -1: Properties of constituents

	Fine Aggregate	Coarse Aggregate	Cement
Specific gravity	2.62	2.68	3.15
Fineness (%)	2.45	7.27	3.52
Sand confirming zone	Zone 3	-	-
Density (kg/m^3)	1701.93	1610.6667	1226.75

6. MIX DESIGN

Table-1: Mix design for M30 concrete

Water	Cement	F.A	C.A
188.781	426	529	1227
0.45	1	1.24	2.88

7. EXPERIMENTAL INVESTIGATION AND MATERIAL PREPARATION

7.1 AGGREGATES TESTING

In this study, I embarked on an in-depth examination of aggregates emphasizing their impact value and shape characteristics. For the Aggregate Impact Value Test, I utilized a 1 kg sample of 10 mm aggregates retained after sieve analysis. The weight of the empty mold was initially recorded as $W1$. The specimen was systematically compressed within a mould, consisting of three separate layers, with each layer subjected to 25 impacts with a tampering rod. Once the sample was set, it was transferred to a steel cup on an impact testing device and the combined weight of the mold and sample was noted as $W2$. The aggregate then underwent the force of a hammer dropped from a height of 380 mm a process repeated five times. After the impacts, the aggregates were sieved through a 2.36 mm mesh with the resultant weight documented as $W3$. Using the weights $W1$, $W2$, and $W3$ in conjunction with a designated formula, we ascertained the effective value of the aggregates.

Additionally, I conducted the Flakiness and Elongation Index Test to evaluate the shape attributes of the aggregates. These assessments are crucial for gauging the aggregates' appropriateness for diverse construction endeavours. Our findings present invaluable insights into the quality and potential applications of aggregates in the realm of construction.
findings offer valuable insights into the quality and applicability of aggregates in the construction industry.

$$Impact\ value = \frac{W_3}{W_2 - W_1} X100$$ ----**Formula 1**

7.2 Materials Preparation

In the subsequent phase of our study, I initiated the concrete mixing process utilizing a concrete mixer. The concrete was uniquely prepared by substituting fine aggregates with rice husk ash in varying proportions: 0%, 0.5%, 1%, 1.5%, and 2%. Once the mix was ready, it was poured into a cubical mold with dimensions of 59.0551 inches on each side and another mold measuring 5.9 x 5.9 x 29.52 inches. To ensure a void-free sample, the concrete was vibrated using a vibrator. The samples were then left undisturbed in the laboratory for 24 hours, post which they were demoulded. For curing, the specimens were submerged in water tanks, with two distinct durations set for curing: seven days and twenty-eight days.

7.3 SLUMP TEST

In order to evaluate the feasibility of the recently made concrete, a slump test was performed. A slump cone mould, with a height of 30.48 cm, a top diameter of 9.906 cm, and a bottom diameter of 20.66 cm, was utilised. The mould was filled in a tri-layered manner, whereby each individual layer underwent compaction with twenty-five repetitions of tamping using a rod. After ensuring the top was level by removing excess concrete with a trowel, the cone was vertically lifted. The resulting slump was observed to be a true slump, indicating the concrete's workable nature.

7.4 COMPRESSIVE STRENGTH AND FLEXURAL STRENGTH

Following the post-curing process, the specimens underwent a compressive strength test. The subjects were situated on the foundation plate of the experimental apparatus, guaranteeing that the loading plunger was in direct contact with the surface of the specimen. The movable component of the machine was then activated, subjecting the specimens to a uniform load of 0.2 MPa. Observations were made, and the peak load at which the specimens exhibited complete fracture was recorded. In addition to the compressive strength test, a flexural strength test was conducted on the rectangular mold, adhering to the Indian standard guidelines. This provided a comprehensive understanding of both the compressive and flexural strengths of the prepared samples.

8. EXPERIMENTAL RESULTS

8.1 IMPACT VALUE TEST

In the study on aggregates, the following measurements were recorded during the Aggregate Impact Value Test:

- **Weight of Empty Cylinder ($W1$)**: The initial weight of the empty cylinder was measured to be 702 grams.
- **Weight of Cylinder Cup with Sample ($W2$)**: Upon adding the aggregate sample to the cylinder cup, the combined weight was determined to be 1025 grams.
- **Weight of Aggregate Passing Through 2.36mm Sieve ($W3$)**: After subjecting the impacted aggregate to sieving, the weight of the material that passed through the 2.36mm sieve was 47 grams.

Based on the above measurements, the calculated **Impact Value** of the aggregate was found to be 14.55%. This value provides insights into the aggregate's resistance to sudden impacts, which is crucial for its application in various construction scenarios.

8.2 FLAKINESS AND ELONGATION

Table 3-: Elongation and flakiness index

Is sieve (passing)	Is sieve (retained)	Sample weight	Weight of aggregate pass-through thickness gauge (gm)	Weight of non-flaky agg (gm)	Weight of aggregate retained on elongation gauge
63	50	0			
50	40	0			
40	31.5	0			
31.5	25	0			
25	20	1285	285	1000	53
20	16	972	72	900	231
16	12.5	464	47	417	24
12.5	10	225	35	190	45
10	6.3	85	20	65	22
		3031	459	2572	375
	Flakiness index (%)	15.14352			
	Elongation index (%)	14.58009			
	Combines	29.72361			

8.3 COMPRESSIVE AND FLEXURAL

Based on an examination of the compressive and flexural strength data, it can be deduced that the concrete specimen integrating a 1.5% substitution of rice husk ash has improved mechanical properties compared to the other samples. The inclusion of an optimal ratio of rice husk ash not only enhances the material's strength, but also offers potential sustainability benefits, therefore establishing it as a promising option for utilisation in construction-related contexts.

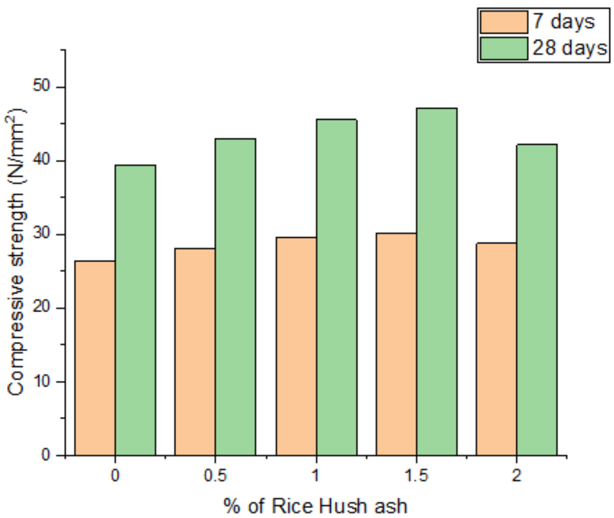

Fig- 1: Graphical Layout of the relation between compressive strength and rice for different days

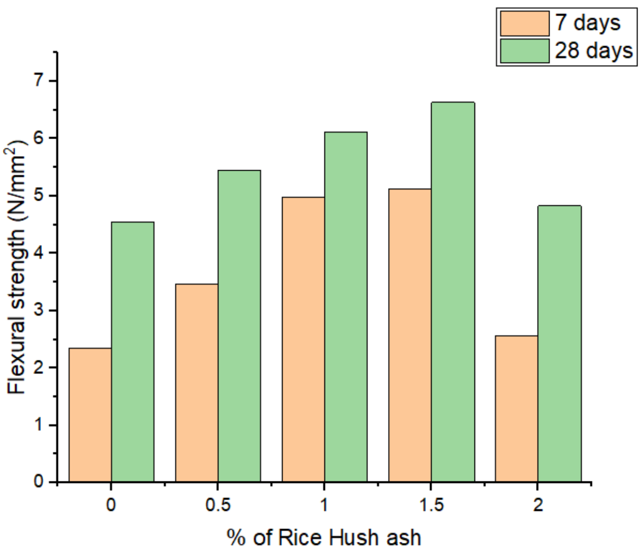

Fig- 2: Graphical Layout of the relation between flexural and rice for different days

Table- 2: Tabulated details of compressive strength for different days

	7 days	28 days
0%	26.32	39.45
0.5%	28.12	43.02
1%	29.65	45.57
1.5%	30.16	47.05
2%	28.78	42.12

Table- 3: Tabulated details of flexural strength for different days

	7 days	28 days
0%	2.35	4.54
0.5%	3.47	5.45
1%	4.98	6.12
1.5%	5.12	6.63
2%	2.56	4.89

The presented table provides an overview of the flexural strength exhibited by concrete specimens after undergoing a curing period of 7 and 28 days. In a manner akin to compressive strength, flexural strength similarly demonstrates a positive correlation with the duration of curing and showcases fluctuations contingent upon the proportion of rice husk ash present.

The results of this study give a detailed analysis of the impact of rice husk ash on the mechanical characteristics of concrete, hence providing significant insights that can be used to many building scenarios.

9. CONCLUSIONS

The extensive examination into the impact of substituting RHA for fine particles in concrete samples has produced informative findings. Compressive and flexural strength tests conducted at two distinct curing durations, namely 7 and 28 days, have allowed for a thorough understanding of the mechanical properties of the concrete samples.

From the data presented:

1. **Compressive Strength**: A distinct pattern of rising strength can be seen in the relationship between the concrete samples' compressive strength and the length of curing. It is worth mentioning that the specimen with a 1.5% replacement of RHA had the maximum compressive strength after 28 days, achieving a value of 47.05 MPa.

2. **Flexural Strength**: The data pertaining to flexural strength likewise shown a positive correlation with the duration of the curing process. The sample with a substitution of 1.5% rice husk ash demonstrated notable performance, exhibiting a flexural strength of 6.63 MPa after 28 days.

The results of the study of the compressive and flexural strength data indicate that the concrete specimen that has 1.5% more rice husk ash replaced by it has better mechanical properties than the other samples. When RHA is added in the right amount, the material becomes stronger and may have sustainability benefits as well, making it a viable option for use in construction.

In conclusion, the study underscores the potential of RHA as a viable replacement for fine aggregates in concrete mixtures. Among the samples tested, the 1.5% rice husk ash replacement sample is identified as the best in terms of its mechanical properties, marking it as a prime candidate for further exploration and application in the construction industry.

REFERENCES

[1] F. A. Oluokun, “Fly Ash Concrete Mix Design and the Water-Cement Ratio Law,” Materials Journal, vol. 91, no. 4, Jul. 1994, pp. 362-371, doi:10.14359/4050.

[2] R. Siddhique, “Effect of fine aggregate replacement with Class F fly ash on the mechanical properties of concrete,” Cement and Concrete Research, vol. 33, no. 4, Apr. 2003, pp. 539-547.

[3] M. Limbachiya, M. S. Meddah, and Y. Ouchagour, “Use of recycled concrete aggregate in fly-ash concrete,” Construction and Building Materials, vol. 27, no. 1, Feb. 2012, pp. 439-449.

[4] P. K. Sarker and P. Nath, “Effect of Fly Ash on the Durability Properties of High Strength Concrete,” Procedia Engineering, vol. 14, 2011, pp. 1149-1156.

[5] O. Kayali and M. N. Haque, “Properties of high-strength concrete using a fine fly ash,” Cement and Concrete Research, vol. 28, no. 10, Oct. 1998, pp. 1445-1452.